AFCCC/TN–96/006

Evaluation of the Homogeneity of Cloud Cover Climatology in Large Scale Regions

By
Capt Anthony J. Warren
Charles R. Coffin

MARCH 1996

Air Force Combat Climatology Center
859 Buchanan Street
Scott Air Force Base, Illinois 62225-5116

REVIEW AND APPROVAL STATEMENT

AFCCC/TN—96/006, *Evaluation of the Homogeneity of Cloud Cover Climatology in Large Scale Regions*, March 1996, has been reviewed and is approved for public release. There is no objection to unlimited distribution of this document to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).

LARRY J. WHITE, Maj, USAF
Chief, Systems Division

JAMES S. PERKINS
Scientific and Technical Information
Program Manager
18 March 1996

REPORT DOCUMENTATION PAGE

2. Report Date: March 1996

3. Report Type: Technical Note

4. Title: Evaluation of the Homogeneity of Cloud Cover Climatology in Large Scale Regions

6. Authors: Capt Anthony J. Warren and Charles R. Coffin

7. Performing Organization Name and Address: Air Force Combat Climatology Center, 859 Buchanan St., Scott AFB, Ill., 62225-5116.

8. Performing Organization Report Number: AFCCC/TN—96/003

12. Distribution/Availability Statement: Approved for public release; distribution unlimited.

13. Abstract: This technical note documents a study AFCCC completed to evaluate the homogeneity of cloud cover distributions within 19 regions known as Consolidated Evaluation Groupings (CEGs). The sizes of these CEGs vary widely and are composed of a variable number of smaller regions known as Post Mission Evaluation regions (PMEs). AFCCC computed the monthly cloud-cover frequency distribution for each of the CEGs and PMEs from the Air Force's Real Time Nephanalysis (RTNEPH) database. In addition, AFCCC conducted a statistical comparison of the PMEs within each CEG to measure the homogeneity of the cloud climatology.

14. Subject Terms: REAL TIME NEPHANALYSIS, CONSOLIDATED EVALUATION GROUPINGS, POST MISSION EVALUATION REGIONS, CHI-SQUARE STATISTIC, PHI-COEFFICIENT, CLOUD COVER CLIMATOLOGY

15. Number of Pages: 28

17. Security Classification of Report: Unclassified

18. Security Classification of this Page: Unclassified

19. Security Classification of Abstract: Unclassified

20. Limitation of Abstract: UL

Standard Form 298

PREFACE

This technical note documents a study AFCCC conducted to evaluate the homogeneity of cloud cover distributions within 19 regions known as Consolidated Evaluation Groupings (CEGs). This technical note documents a study AFCCC completed to evaluate the homogeneity of cloud cover distributions within 19 regions known as Consolidated Evaluation Groupings (CEGs). The sizes of these CEGs vary widely and are composed of a variable number of smaller regions known as Post Mission Evaluation regions (PMEs). AFCCC computed the monthly cloud-cover frequency distributions for each of the CEGs and PMEs from the Air Force's Real Time Nephanalysis (RTNEPH) database. In addition, AFCCC conducted a statistical comparison of the PMEs within each CEG to measure the homogeneity of the cloud climatology.

CONTENTS

CHAPTER 1. INTRODUCTION 1
1.1 Background 1

CHAPTER 2. STATISTICAL METHODS 3
2.1 Comparison of Distributions 3
2.2 Cloud Cover Data 3
2.3 Interpretation of the Phi-Coefficient 3
2.4 Results 4

APPENDIX DEFINITION OF CONSOLIDATED EVALUATION GROUPS (CEGS) 15

REFERENCES 17

FIGURES

Figure 1. Comparison of two distributions with a phi-coefficient of 0.05 4

Figure 2. Comparison of two distributions with a phi-coefficient of 0.20 4

Figure 3. Comparison of two distributions with a phi-coefficient of 0.35 4

Figure 4. Comparison of two distributions with a phi-coefficient of 0.50 4

Figure 5. Frequency distribution of phi-coefficients 4

TABLES

Table 1. PME regions which had similar cloud cover climatologies to their corresponding CEGs 4

Table 2. PME regions which had dissimilar cloud cover climatologies to their corresponding CEGs 6

Table 3. Possible alternative CEG regions for PME regions listed in Table 2 7

Table 4. Listing of the phi-coefficients for the comparison, by month, of each PME region with its original CEG 8

Table 5. Listing of the bad months for the CEGs that can be considered reasonable alternatives to the original CEGs (see Table 3) 10

Table 6. Listing of the phi-coefficients for the comparison, by month, of each PME region for the alternative CEGs. 13

Chapter 1

INTRODUCTION

1.1 Background. AFCCC (formerly designated USAFETAC) completed a study to evaluate the homogeneity of cloud cover distributions within 19 regions known as Consolidated Evaluation Groupings (CEGs). The sizes of these CEGs vary widely and are composed of a variable number of smaller regions known as Post Mission Evaluation regions (PMEs). AFCCC computed the monthly cloud-cover frequency distributions for each of the CEGs and PMEs from the Air Force's Real Time Nephanalysis (RTNEPH) database. In addition, AFCCC conducted a statistical comparison of the PMEs within each CEG to measure the homogeneity of the cloud climatology. The appendix contains a listing of the PMEs within each CEG.

Cloud climatology can vary greatly over very small distances, so caution must be used in concluding that the climatology in a given region is homogeneous. This study is a measure of the similarity of large-scale climatological features.

Chapter 2

STATISTICAL METHODS

2.1 Comparison of Distributions. Testing the hypothesis, "Are two distributions statistically similiar?" is not straightforward since the term similiar is not precisely defined. The usual test hypothesis for comparing two distributions is, "Are two distributions statistically the same?" The chi-square test is used to evaluate this hypothesis. For each data category, the expected number E_i of observations, assuming the test hypothesis is true, is compared against the observed number of observations, O_i. The chi-square statistic, χ^2 is then calculated using (Fleiss, 1973):

$$\chi^2 = \sum_{i=1}^{N} \frac{(E_i - O_i)^2}{E_i}$$

where N is the total number of categories. This value is then compared against a critical value. If χ^2 exceeds this critical value, the test hypothesis is rejected.

There are several problems with the chi-square test. Primarily, it is very sensitive to sample size. Large sample sizes generally result in the test hypothesis being rejected; smaller samples result in the hypothesis being accepted. In addition, the test hypothesis is often too restrictive. Very often, the user is interested in knowing if two distributions are similar, not necessarily statistically identical. To overcome these two deficiencies, the phi-coefficient can be used. This coefficient is defined as (Fleiss, 1973):

$$\phi = \sqrt{\frac{\chi^2}{N}}$$

Values of the phi-coefficient close to zero indicate two distributions are nearly identical. Values around one indicate little similarity.

2.2 Cloud Cover Data. The cloud cover frequency distributions used in this study were initially divided into 21 classes. Class number 1 represented a cloud cover of zero percent. Class number 2 represented one to five percent, number 3 represented six to ten percent, and so on up to class number 21 which represented 100 percent cloud cover. The relative frequency of several classes was very small (in many cases less than one percent). It is inadvisable to compute the chi-square statistic when classes have a low count. To overcome this we combined the original 21 classes into six larger classes:

- Class 1 (Old Class 1)
- Class 2 (Old Classes 2, 3, 4, 5, 6)
- Class 3 (Old Classes 7, 8, 9, 10, 11)
- Class 4 (Old Classes 12, 13, 14, 15)
- Class 5 (Old Classes 16, 17, 18, 19, 20)
- Class 6 (Old Class 21)

Chi-square and phi-coefficient values were computed for the cloud-cover frequency distribution of each PME and the corresponding CEG it was located within. A large amount of data was processed, as the monthly sample corresponding size within each PME was on the order of 10^6.

2.3 Interpretation of the Phi-Coefficient. The phi-coefficient is a relative measure of the similarity of two distributions. As a guide to interpreting its significance, we have provided a comparison of four distribution sets for different values of the phi-coefficient: 0.05 (Figure 1), 0.20 (Figure 2), 0.35 (Figure 3), and 0.50 (Figure 4).

As a further guide to interpreting the phi-coefficient, Figure 5 depicts a plot of the relative frequency distribution and the cumulative frequency distribution of values of phi computed in this study. Based on the plots in Figures 1 through 5, we selected a value of phi of 0.35 as the discriminant between similar and non-similar distributions. About three-quarters of the distributions in this study were therefore classified as similar. In evaluating whether the cloud-cover climatology of a given PME was similar to that of the large CEG we used the following criterion: If the value of phi is less than 0.35 for 8 out of the 12 months, the climatologies are *similar*, otherwise the climatologies are classified as *dissimilar*.

2.4 Results. Table 1 lists those PME regions whose cloud-cover climatologies are similar to its corresponding CEG (see the appendix for a definition of each CEG). Table 2 lists those PME regions whose cloud-cover climatologies are dissimilar to its

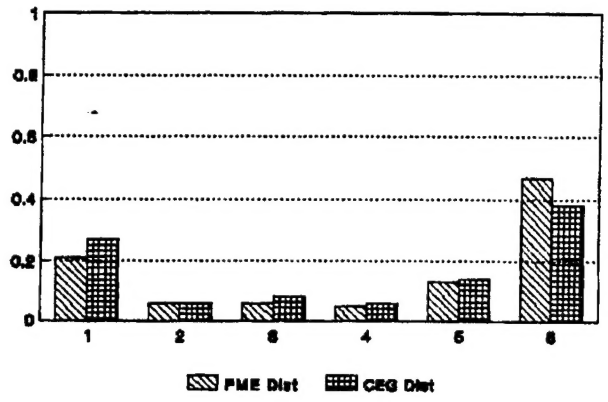

Figure 1. Comparison of two distributions with a phi-coefficient of 0.05.

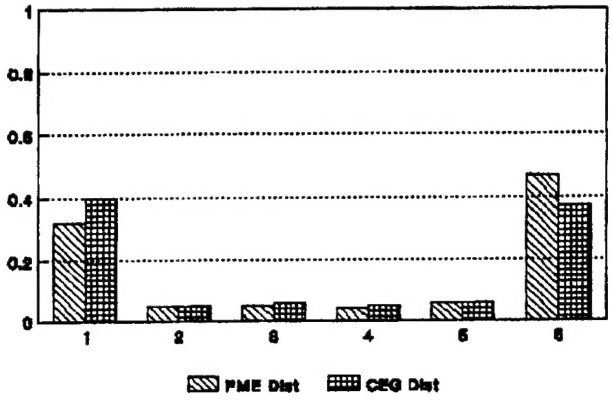

Figure 2. Comparison of two distributions with a phi-coefficient of 0.20.

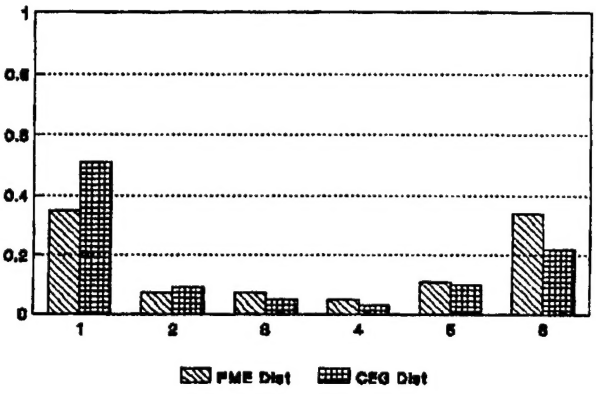

Figure 3. Comparison of two distributions with a phi-coefficient of 0.35.

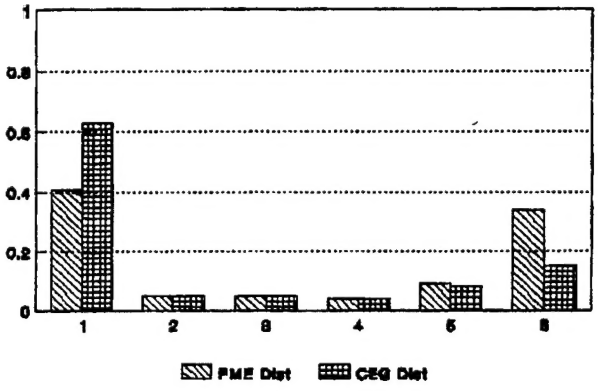

Figure 4. Comparison of two distributions with a phi-coefficient of 0.50.

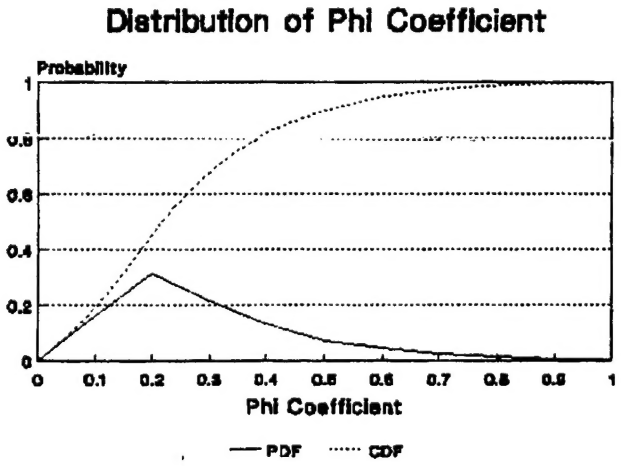

Figure 5. Frequency distribution of phi-coefficients.

corresponding CEG. We conducted further analysis on these PME regions, comparing them against the remaining 18 CEGs to determine if this PME might better belong in one of these other regions. (We made no consideration for the proximity of the PME region to the CEG). Table 4 lists those CEGs in which at least three additional months had a phi-coefficient lower than 0.35. In some cases, no acceptable substitutes were found. Finally, Table 5 is listing of the phi-coefficients computed, by month, for the comparison of each PME region with its originally assigned CEG.

Due to the large numbers of bad matches in CEG 1, we broke this region up into two CEGs: 1a and 20. CEG 1a excluded the two arctic regions (1111 Antarctica and 1121 Arctic Ocean) which were

transferred to CEG 20. The monthly values of phi for these two regions are listed in Table 6. The PME regions in CEG 1a now all showed similar climatologies. The new arctic CEG however indicated a poor fit. Because the climatologies of the two regions are 6 months out of phase, we also compared results for a 6-month shift of region 1111. The comparison was still poor. There is some uncertainty if this indicates a real difference in climatology, or is an artifact of the RTNEPH, which has been shown to have difficulty discriminating between ice-cover and cloud-cover (Lowther et al., 1991).

Table 1. PME regions that had similar cloud cover climatologies to their corresponding CEGs.

CEG	PMEs
1	1111
2	117-124-125-126-127-512-514
3	111-112-113-114-116-211
4	152-212
5	118-141-143-145-154
6	115-151-221-222
7	323-324
8	144-146-147-415-417
9	312-313-321-931-932-933-934-935
10	723-732-741-913-914
11	721
12	915
13	413-414-1011
14	731-742-923
15	513
16	1012
17	133-134-1222-1243-1311-1312-1324-1334-1433-1434
18	135-422-1211-1223-1235-1241-1242-1313-1322-1323-1332-1333-1432
19	622-1212-1213-1214-1231-1232-1233-1321-1331-1421-1422

Table 2. PME regions that had dissimilar cloud cover climatologies with their corresponding CEG.

CEG	PMEs
1	121-122-123-214-511-1121
2	1221
3	*none*
4	213
5	119
6	*none*
7	142-325
8	153-416
9	311-314-315-322-936
10	743
11	612-621-624-711-712-722
12	911-912-921-937
13	411-412
14	731-742-923
15	513
16	1013
17	131-132
18	*none*
19	421-623-1234-1411

Table 3. Possible alternative CEG regions for PME regions listed in Table 2.

CEG	PME	No of bad months	Alternates [Number of bad months in ()]
1	121	10	12(2), 5(7), 11(7), 14(7), 16(7)
	122	11	7(6), 11(7), 12(7), 5(8)
	123	11	12(6), 16(7), 19(7), 5(8), 7(8), 11(8), 14(8)
	214	7	12(1), 19(2), 18(3), 11(4)
	511	7	19(0), 12(2)
	1121	9	19(4), 14(5), 16(6)
2	1221	10	13(0), 17(0), 18(2), 11(4), 3(5)
4	213	6	no satisfactory alternate
5	119	6	10(0), 14(2), 16(2), 6(3)
7	142	8	5(3)
	325		18(2), 8(4), 12(4), 11(5), 13(5), 17(5), 2(6), 19(6)
8	153	7	5(4)
	416	6	5(4)
9	311	9	no satisfactory alternate
	314	7	no satisfactory alternate
	315	5	no satisfactory alternate
	322	6	16(3)
	936	7	7(4)
10	743	7	14(2), 5(4)
11	612	9	17(6)
	621		6(10)
	624	11	18(8)
	711	6	13(3), 17(3)
	712		2(1), 8(3), 12(3), 18(4)
	732	5	no satisfactory alternate
12	911	6	no satisfactory alternate
	912	6	11(2), 18(3)
	921	5	6(0), 10(1), 14(1)
	937	7	5(2), 14(4)
13	411	7	no satisfactory alternate
	412	5	no satisfactory alternate
14	611	5	5(3)
	922	5	10(3)
16	1013	12	4(1), 8(2), 3(3), 11(3), 18(3), 2(6), 6(6)
17	131	6	12(3), 18(4), 19(4)
	132	8	11(2), 12(4), 18(4), 19(4)
19	421	6	no satisfactory alternate
	623	5	14(0), 16(3)
	1234	6	16(0), 14(1), 5(3), 10(3)
	1411	6	no satisfactory alternate
	1412	5	no satisfactory alternate

Table 4. Listing of the phi-coefficients for the comparison, by month, of each PME region with its original CEG.

CEG	PME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	121	0.43	0.61	0.58	0.72	0.54	0.47	0.55	0.56	0.33	0.40	0.33	0.46
1	122	0.60	0.69	0.76	0.71	0.63	0.56	0.57	0.54	0.34	0.44	0.56	0.57
1	123	0.47	0.65	0.84	0.79	0.55	0.55	0.57	0.47	0.22	0.47	0.58	0.59
1	214	0.32	0.47	0.45	0.57	0.36	0.31	0.45	0.45	0.23	0.29	0.30	0.39
1	511	0.24	0.39	0.54	0.52	0.36	0.37	0.47	0.39	0.12	0.24	0.24	0.26
1	1111	0.16	0.28	0.35	0.39	0.30	0.27	0.35	0.28	0.38	0.21	0.23	0.20
1	1121	0.24	0.37	0.50	0.73	0.83	0.71	0.80	0.61	0.32	0.59	0.52	0.26
2	117	0.14	0.16	0.13	0.14	0.15	0.13	0.16	0.16	0.11	0.18	0.14	0.12
2	124	0.31	0.25	0.11	0.12	0.12	0.12	0.10	0.09	0.09	0.10	0.23	0.29
2	125	0.26	0.19	0.30	0.19	0.10	0.13	0.10	0.11	0.13	0.17	0.30	0.31
2	126	0.41	0.47	0.29	0.26	0.18	0.16	0.29	0.23	0.08	0.17	0.36	0.42
2	127	0.40	0.30	0.08	0.09	0.07	0.08	0.15	0.11	0.17	0.35	0.29	0.32
2	512	0.14	0.14	0.14	0.16	0.17	0.16	0.19	0.21	0.13	0.11	0.14	0.12
2	514	0.20	0.13	0.11	0.11	0.17	0.19	0.20	0.29	0.26	0.13	0.14	0.23
2	1221	0.50	0.52	0.36	0.28	0.36	0.39	0.43	0.48	0.42	0.31	0.46	0.54
3	111	0.14	0.16	0.12	0.05	0.34	0.19	0.21	0.18	0.15	0.27	0.18	0.22
3	112	0.14	0.10	0.11	0.14	0.22	0.06	0.17	0.17	0.19	0.28	0.12	0.15
3	113	0.12	0.08	0.07	0.08	0.16	0.09	0.13	0.16	0.15	0.20	0.10	0.10
3	114	0.21	0.15	0.10	0.12	0.21	0.09	0.15	0.20	0.12	0.14	0.13	0.19
3	116	0.15	0.13	0.30	0.14	0.10	0.15	0.14	0.22	0.14	0.13	0.19	0.16
3	211	0.22	0.22	0.26	0.21	0.17	0.18	0.22	0.26	0.22	0.23	0.24	0.23
4	152	0.25	0.25	0.25	0.19	0.22	0.10	0.25	0.27	0.15	0.33	0.22	0.21
4	212	0.07	0.08	0.07	0.05	0.05	0.02	0.05	0.07	0.04	0.08	0.08	0.07
4	213	0.21	0.28	0.29	0.33	0.40	0.36	0.50	0.45	0.47	0.38	0.24	0.23
5	118	0.46	0.24	0.18	0.12	0.12	0.29	0.26	0.28	0.12	0.23	0.41	0.52
5	119	0.42	0.29	0.28	0.10	0.25	0.51	0.55	0.56	0.48	0.14	0.17	0.40
5	141	0.16	0.14	0.18	0.09	0.12	0.14	0.09	0.09	0.09	0.15	0.14	0.16
5	143	0.27	0.20	0.23	0.19	0.22	0.34	0.26	0.29	0.33	0.17	0.23	0.33
5	145	0.32	0.26	0.19	0.07	0.12	0.24	0.38	0.39	0.24	0.10	0.17	0.34
5	154	0.33	0.30	0.31	0.14	0.13	0.19	0.22	0.20	0.12	0.08	0.21	0.30
6	115	0.34	0.31	0.28	0.22	0.18	0.30	0.37	0.28	0.35	0.26	0.33	0.37
6	151	0.19	0.19	0.24	0.15	0.20	0.35	0.23	0.18	0.09	0.14	0.16	0.09
6	221	0.13	0.13	0.07	0.16	0.15	0.34	0.36	0.30	0.37	0.14	0.15	0.11
6	222	0.28	0.23	0.25	0.14	0.09	0.13	0.14	0.13	0.15	0.19	0.22	0.27
7	142	0.17	0.35	0.38	0.37	0.38	0.56	0.64	0.56	0.47	0.32	0.26	0.21
7	323	0.14	0.09	0.12	0.18	0.23	0.15	0.08	0.05	0.13	0.27	0.26	0.17
7	324	0.08	0.19	0.17	0.07	0.19	0.46	0.28	0.28	0.36	0.34	0.30	0.06
7	325	0.90	0.43	0.46	0.72	0.65	0.31	0.23	0.09	0.29	0.87	1.09	0.90
8	144	0.11	0.09	0.05	0.08	0.08	0.11	0.20	0.18	0.19	0.13	0.07	0.09
8	146	0.24	0.23	0.21	0.23	0.21	0.19	0.14	0.25	0.26	0.23	0.32	0.31
8	147	0.11	0.15	0.15	0.11	0.10	0.08	0.23	0.06	0.13	0.11	0.08	0.19
8	153	0.57	0.62	0.61	0.50	0.37	0.21	0.27	0.15	0.31	0.43	0.41	0.29
8	415	0.47	0.40	0.31	0.16	0.10	0.11	0.08	0.15	0.19	0.30	0.38	0.52
8	416	0.35	0.36	0.38	0.45	0.39	0.25	0.19	0.26	0.25	0.36	0.32	0.26
8	417	0.33	0.33	0.29	0.32	0.30	0.23	0.43	0.33	0.23	0.29	0.38	0.38
9	311	0.67	0.59	0.43	0.23	0.24	0.37	0.55	0.49	0.44	0.32	0.41	0.61
9	312	0.29	0.22	0.21	0.15	0.04	0.47	0.65	0.58	0.58	0.05	0.30	0.34
9	313	0.15	0.14	0.12	0.05	0.21	0.19	0.12	0.19	0.31	0.37	0.26	0.14
9	314	0.33	0.37	0.39	0.24	0.09	0.37	0.36	0.41	0.51	0.19	0.18	0.39
9	315	0.08	0.09	0.06	0.35	0.25	0.55	0.68	0.65	0.53	0.32	0.14	0.03
9	321	0.15	0.21	0.33	0.06	0.15	0.07	0.34	0.14	0.33	0.37	0.19	0.21
9	322	0.61	0.71	0.72	0.34	0.09	0.25	0.33	0.41	0.42	0.12	0.26	0.69
9	931	0.21	0.25	0.26	0.16	0.11	0.05	0.07	0.07	0.28	0.13	0.39	0.23
9	932	0.24	0.25	0.16	0.17	0.21	0.25	0.33	0.29	0.21	0.34	0.30	0.18
9	933	0.13	0.02	0.04	0.20	0.15	0.35	0.66	0.63	0.40	0.20	0.07	0.09
9	934	0.04	0.10	0.09	0.10	0.10	0.12	0.19	0.28	0.24	0.08	0.04	0.07

Table 4 (continued).

CEG	PME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
9	935	0.31	0.28	0.15	0.24	0.17	0.26	0.40	0.46	0.42	0.19	0.23	0.28
9	936	0.13	0.08	0.10	0.46	0.44	0.48	0.50	0.38	0.36	0.37	0.13	0.12
10	723	0.05	0.08	0.12	0.16	0.16	0.16	0.16	0.12	0.15	0.10	0.13	0.11
10	732	0.08	0.06	0.06	0.12	0.15	0.06	0.14	0.12	0.07	0.06	0.04	0.06
10	741	0.51	0.50	0.43	0.19	0.13	0.26	0.30	0.31	0.19	0.07	0.23	0.50
10	743	0.42	0.40	0.28	0.12	0.25	0.51	0.55	0.74	0.53	0.29	0.12	0.42
10	913	0.21	0.19	0.04	0.17	0.30	0.32	0.29	0.29	0.32	0.12	0.09	0.13
10	914	0.24	0.27	0.16	0.10	0.13	0.14	0.14	0.14	0.15	0.14	0.11	0.08
11	612	0.63	0.72	0.75	0.53	0.23	0.50	0.63	0.64	0.42	0.23	0.26	0.42
11	621	0.80	0.82	0.82	0.89	0.61	0.43	0.42	0.35	0.41	0.53	0.69	0.67
11	624	0.72	0.74	0.78	0.72	0.48	0.35	0.36	0.35	0.28	0.40	0.55	0.68
11	711	0.16	0.10	0.04	0.28	0.43	0.55	0.60	0.65	0.40	0.37	0.18	0.17
11	712	0.43	0.41	0.37	0.16	0.21	0.39	0.43	0.38	0.08	0.07	0.08	0.32
11	713	0.26	0.26	0.22	0.23	0.12	0.16	0.26	0.26	0.09	0.13	0.07	0.07
11	721	0.18	0.18	0.20	0.22	0.38	0.27	0.26	0.13	0.26	0.22	0.17	0.13
11	722	0.35	0.35	0.34	0.16	0.20	0.40	0.47	0.44	0.44	0.07	0.12	0.32
12	911	0.48	0.45	0.29	0.23	0.09	0.32	0.40	0.38	0.15	0.20	0.43	0.44
12	912	0.57	0.56	0.34	0.21	0.10	0.38	0.42	0.27	0.16	0.33	0.50	0.61
12	915	0.13	0.04	0.14	0.16	0.26	0.33	0.38	0.33	0.22	0.29	0.11	0.12
12	921	0.33	0.17	0.15	0.21	0.29	0.44	0.57	0.58	0.93	0.45	0.19	0.26
12	937	0.42	0.43	0.35	0.08	0.25	0.24	0.26	0.45	0.63	0.37	0.23	0.38
13	411	1.25	1.22	0.95	0.57	0.23	0.30	0.35	0.42	0.17	0.25	0.62	1.17
13	412	0.40	0.40	0.54	0.52	0.21	0.21	0.24	0.26	0.11	0.13	0.15	0.37
13	413	0.14	0.10	0.10	0.07	0.16	0.09	0.12	0.19	0.13	0.27	0.23	0.16
13	414	0.31	0.31	0.26	0.14	0.10	0.18	0.21	0.27	0.39	0.12	0.07	0.27
13	1011	0.36	0.47	0.36	0.33	0.12	0.08	0.07	0.12	0.16	0.08	0.12	0.34
14	611	0.35	0.39	0.39	0.25	0.16	0.31	0.49	0.46	0.13	0.18	0.31	0.26
14	731	0.37	0.33	0.36	0.29	0.29	0.16	0.09	0.08	0.08	0.14	0.19	0.22
14	742	0.19	0.22	0.12	0.14	0.49	0.58	0.56	0.46	0.20	0.21	0.10	0.13
14	922	0.22	0.27	0.23	0.10	0.44	0.63	0.66	0.54	0.39	0.07	0.17	0.21
14	923	0.33	0.23	0.31	0.24	0.26	0.23	0.33	0.33	0.35	0.13	0.16	0.25
15	513	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	1012	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.06	0.05	0.03	0.03
16	1013	0.47	0.46	0.53	0.60	0.72	0.78	0.82	0.98	1.13	0.93	0.65	0.52
17	131	0.21	0.45	0.71	0.57	0.41	0.67	0.33	0.33	0.37	0.18	0.22	0.25
17	132	0.37	0.52	0.41	0.76	0.54	0.57	0.72	0.41	0.14	0.16	0.10	0.21
17	133	0.16	0.17	0.14	0.22	0.13	0.14	0.21	0.22	0.27	0.30	0.27	0.18
17	134	0.31	0.30	0.13	0.13	0.28	0.28	0.29	0.24	0.12	0.10	0.24	0.33
17	1222	0.19	0.08	0.14	0.11	0.13	0.19	0.21	0.17	0.05	0.17	0.22	0.16
17	1243	0.04	0.04	0.05	0.07	0.04	0.05	0.05	0.07	0.04	0.05	0.05	0.04
17	1311	0.08	0.09	0.10	0.15	0.17	0.16	0.12	0.16	0.23	0.14	0.18	0.19
17	1312	0.29	0.24	0.27	0.19	0.13	0.08	0.11	0.13	0.18	0.29	0.20	0.22
17	1324	0.25	0.21	0.13	0.13	0.21	0.28	0.39	0.32	0.15	0.12	0.18	0.27
17	1334	0.18	0.17	0.14	0.05	0.06	0.08	0.08	0.09	0.20	0.22	0.19	0.24
17	1433	0.06	0.04	0.03	0.02	0.04	0.07	0.11	0.09	0.19	0.05	0.04	0.07
17	1434	0.08	0.05	0.05	0.04	0.09	0.13	0.14	0.15	0.30	0.17	0.14	0.10
18	135	0.20	0.17	0.24	0.35	0.23	0.19	0.32	0.22	0.13	0.23	0.14	0.14
18	422	0.25	0.30	0.30	0.25	0.23	0.24	0.14	0.14	0.09	0.15	0.12	0.13
18	1211	0.31	0.28	0.20	0.17	0.22	0.26	0.26	0.20	0.12	0.08	0.08	0.22
18	1223	0.16	0.11	0.10	0.11	0.10	0.19	0.19	0.12	0.03	0.02	0.06	0.11
18	1235	0.11	0.06	0.03	0.04	0.14	0.20	0.23	0.22	0.11	0.12	0.12	0.09
18	1241	0.23	0.19	0.16	0.06	0.11	0.17	0.21	0.20	0.21	0.24	0.14	0.23
18	1242	0.12	0.12	0.12	0.17	0.22	0.21	0.23	0.24	0.25	0.09	0.13	0.12
18	1313	0.27	0.24	0.18	0.25	0.16	0.19	0.34	0.40	0.22	0.18	0.21	0.16
18	1322	0.12	0.13	0.16	0.22	0.31	0.41	0.50	0.53	0.22	0.19	0.16	0.12
18	1323	0.07	0.06	0.17	0.26	0.22	0.22	0.23	0.20	0.12	0.12	0.12	0.05
18	1333	0.18	0.15	0.14	0.11	0.07	0.09	0.11	0.15	0.16	0.09	0.15	0.15
18	1431	0.10	0.12	0.05	0.06	0.10	0.17	0.25	0.21	0.23	0.14	0.06	0.05
18	1432	0.16	0.14	0.18	0.11	0.20	0.20	0.14	0.17	0.11	0.07	0.12	0.13

Table 4 (continued).

CEG	PME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
19	421	0.15	0.21	0.18	0.13	0.32	0.52	0.46	0.53	0.44	0.47	0.42	0.13
19	622	0.62	0.58	0.54	0.32	0.08	0.19	0.13	0.13	0.10	0.19	0.22	0.45
19	623	0.26	0.28	0.24	0.37	0.45	0.17	0.19	0.30	0.38	0.41	0.40	0.22
19	1212	0.14	0.23	0.09	0.11	0.15	0.33	0.44	0.45	0.26	0.25	0.19	0.20
19	1213	0.14	0.15	0.05	0.06	0.05	0.06	0.04	0.09	0.10	0.05	0.06	0.15
19	1214	0.05	0.10	0.07	0.05	0.17	0.20	0.28	0.27	0.16	0.18	0.12	0.09
19	1231	0.45	0.63	0.41	0.31	0.18	0.12	0.10	0.06	0.15	0.09	0.26	0.44
19	1232	0.14	0.10	0.03	0.10	0.13	0.29	0.37	0.43	0.53	0.32	0.23	0.10
19	1233	0.30	0.27	0.16	0.10	0.11	0.20	0.32	0.30	0.46	0.13	0.15	0.26
19	1234	0.38	0.26	0.17	0.18	0.36	0.37	0.40	0.38	0.61	0.29	0.30	0.33
19	1321	0.15	0.12	0.07	0.08	0.09	0.04	0.04	0.05	0.11	0.10	0.15	0.07
19	1331	0.20	0.16	0.07	0.09	0.26	0.38	0.37	0.33	0.53	0.19	0.13	0.12
19	1411	0.13	0.30	0.15	0.17	0.48	0.70	0.62	0.76	0.57	0.47	0.32	0.06
19	1412	0.29	0.54	0.49	0.38	0.18	0.27	0.16	0.24	0.20	0.39	0.42	0.29
19	1421	0.34	0.26	0.20	0.14	0.20	0.09	0.16	0.12	0.13	0.17	0.13	0.06
19	1422	0.29	0.20	0.08	0.10	0.09	0.19	0.22	0.16	0.23	0.14	0.19	0.11

Table 5. Listing of the bad months for the CEGs that can be considered reasonable alternatives to the original CEGs (see Table 3).

OLD CEG	PME	CEG	NUMBER OF BAD MONTHS WITH INDIVIDUAL MONTHS LISTED
1	121	12	2 MAR APR
1	121	5	7 MAY JUN JUL AUG SEP OCT NOV
1	121	11	7 JAN FEB MAR APR MAY NOV DEC
1	121	14	7 FEB MAY JUN JUL AUG SEP OCT
1	121	16	7 MAY JUN JUL AUG SEP OCT NOV
1	122	7	6 FEB MAY JUL AUG OCT NOV
1	122	11	7 JAN FEB MAR APR MAY NOV DEC
1	122	12	7 JAN FEB MAR APR MAY NOV DEC
1	122	5	8 MAR APR MAY JUN JUL AUG SEP OCT
1	123	12	6 FEB MAR APR MAY NOV DEC
1	123	16	7 FEB MAR JUN JUL AUG SEP OCT
1	123	19	7 JAN FEB MAR APR SEP NOV DEC
1	123	5	8 MAR APR MAY JUN JUL AUG SEP OCT
1	123	7	8 JAN FEB MAY JUN JUL AUG OCT NOV
1	123	11	8 JAN FEB MAR APR MAY OCT NOV DEC
1	123	14	8 JAN FEB MAR APR MAY AUG SEP DEC
1	214	12	1 APR
1	214	19	2 SEP OCT
1	214	18	3 FEB APR DEC
1	214	11	4 FEB MAR APR DEC
1	511	19	0
1	511	12	2 MAR APR
1	1121	19	4 MAR APR MAY NOV
1	1121	14	5 JAN FEB MAR APR MAY
1	1121	16	6 JAN MAR APR AUG SEP OCT
2	1221	13	0
2	1221	17	0
2	1221	18	2 AUG SEP
2	1221	11	4 JUN JUL AUG SEP
2	1221	3	5 MAY JUN JUL AUG SEP
5	119	10	0
5	119	14	2 AUG SEP
5	119	16	2 JAN DEC
5	119	6	3 JUN SEP NOV
7	142	5	3 AUG NOV DEC

Table 5 (continued).

OLD CEG	PME	CEG	NUMBER OF BAD MONTHS WITH INDIVIDUAL MONTHS LISTED
7	325	18	2 FEB MAR
7	325	8	4 FEB MAR JUL AUG
7	325	12	4 JAN MAR JUN AUG
7	325	11	5 FEB MAR JUN JUL AUG
7	325	13	5 JAN FEB MAR APR DEC
7	325	17	5 JAN FEB MAR APR DEC
7	325	2	6 JAN FEB MAR APR JUN AUG
7	325	19	6 FEB MAY JUN JUL AUG OCT
8	153	5	4 JUN JUL AUG SEP
8	416	5	4 JUN JUL AUG SEP
9	322	16	3 JUN JUL SEP
9	936	7	4 JUN JUL AUG SEP
10	743	14	2 JUN AUG
10	743	5	4 JAN FEB AUG OCT
11	612	17	6 JAN FEB MAR APR NOV DEC
11	621	6	10 JAN FEB MAR APR JUN JUL AUG SEP NOV DEC
11	624	18	8 JAN FEB MAR APR MAY OCT NOV DEC
11	711	13	3 JAN FEB DEC
11	711	17	3 JAN FEB DEC
11	712	2	1 JAN
11	712	8	3 JAN FEB MAR
11	712	12	3 MAY JUN JUL
11	712	18	4 JAN FEB MAR DEC
12	912	11	2 JUN JUL
12	912	18	3 JUN JUL AUG
12	921	6	0
12	921	10	1 APR
12	921	14	1 SEP
12	937	5	2 JAN APR
12	937	14	4 JAN FEB APR DEC
14	611	5	3 JUL AUG SEP
14	922	10	3 MAY JUN JUL

Table 5 (continued).

OLD CEG	PME	CEG	NUMBER OF BAD MONTHS WITH INDIVIDUAL MONTHS LISTED
16	1013	4	1 DEC
16	1013	8	2 MAR DEC
16	1013	3	3 JAN FEB MAR
16	1013	11	3 JUL AUG SEP
16	1013	18	3 FEB MAR SEP
16	1013	2	6 JAN FEB MAR APR SEP DEC
16	1013	6	6 MAY JUN JUL AUG SEP OCT
17	131	12	3 JAN NOV DEC
17	131	18	4 MAR JUN NOV DEC
17	131	19	4 JAN OCT NOV DEC
17	132	11	2 APR OCT
17	132	12	4 JAN OCT NOV DEC
17	132	18	4 APR JUL SEP OCT
17	132	19	4 SEP OCT NOV DEC
19	623	14	0
19	623	16	3 JUL AUG SEP
19	1234	16	0
19	1234	14	1 SEP
19	1234	5	3 MAY JUN JUL
19	1234	10	3 JAN FEB DEC

Table 6. Listing of the phi-coefficients for the comparison, by month, of each PME region for the alternative CEGs.

CEG	PME	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1a	121	0.21	0.22	0.22	0.23	0.21	0.17	0.12	0.16	0.17	0.17	0.13	0.19
1a	122	0.32	0.25	0.20	0.15	0.24	0.19	0.14	0.17	0.18	0.19	0.26	0.25
1a	123	0.21	0.21	0.27	0.23	0.19	0.24	0.16	0.13	0.12	0.23	0.29	0.26
1a	214	0.36	0.31	0.33	0.27	0.23	0.15	0.09	0.09	0.14	0.16	0.26	0.23
1a	511	0.11	0.12	0.10	0.11	0.10	0.08	0.08	0.09	0.08	0.08	0.09	0.12
20	1111	0.07	0.11	0.15	0.18	0.17	0.13	0.16	0.12	0.23	0.11	0.11	0.08
20	1121	0.64	0.70	0.67	0.88	0.81	0.58	0.64	0.63	0.58	0.93	0.91	0.65

Appendix

DEFINITION OF CONSOLIDATED EVALUATION GROUPS (CEGs)

1. POLAR REGIONS

121	Kara Sea and Coast
122	Laptev Sea and Coast
123	Chukchi Sea and Coast
214	Svalbard
511	Greenland and Arctic Ocean
1111	Antarctica
1121	Arctic Ocean

2. SUBARCTIC REGION

117	Western Siberia
124	Central Siberia
125	Eastern Siberia
126	Kamchatka and Kuril Islands
127	Soviet Amur and Vladivostok
512	Canada
514	Mainland Alaska
1221	Bering Sea and Aleutians

3. RUSSIAN REGION

111	Barents Sea Coast
112	Western Russia
113	Northwest Russia
114	Moscow Rectangle
116	Gorkiy - Sverdlovsk
211	Scandinavia - Baltic Sea

4. NORTHERN EUROPEAN REGION

152	Northern Eastern Europe
212	NW Europe - North Sea
213	Iceland

5. NORTHERN CHINA REGION

118	Kazakhstan
119	South Soviet Asia
141	Northwest China
143	North Central China
154	North East China
154	Mongolia

6. MEDITERRANEAN REGION

115	Southwest Russia
151	Southern Eastern Europe
221	Greece and Turkey
222	W Mediterranean

7. INDIAN REGION

142	Tibet
323	Northern India, Bangladesh
324	Southern India
325	Sri Lanka

8. ASIAN EAST COASTAL REGION

144	South Central Asia
146	East China
147	Southeast China
153	North Korea
415	Japan
416	South Korea
417	Taiwan

9. ARID REGION

311	Israel and Adjacent States
312	Iraq
313	Arabian Peninsula
314	Iran
315	Egypt
321	Pakistan
322	Afghanistan
931	W Sahara & Mauritania
932	Morocco & Algeria
933	Libya
934	Mali & Niger
935	Chad & Sudan
936	Horn of Africa

10. SOUTHERN HEMISPHERE CONTINENTAL

723	Southeast Brazil
732	Bolivia & Paraguay
741	Northern Argentina
743	Uruguay
913	Southeast Africa
914	Madagascar

11. TROPICAL AMERICANA

612	Central America
621	Cuba
624	Antilles & Bahamas
711	Columbia & Northern Ecuador
712	Venezuela & Guianas
713	S Ecuador & S Colombia
721	Northern Brazil
722	Amazon Brazil

12. AFRICAN TROPICS

911	Humid West Africa
912	S Congo, S Gabon, S Za re
915	Humid Central Africa
921	Tanzania & S Kenya
937	N Uganda & N Kenya

13. ASIAN TROPICS

411	Southeast Asia
412	Philippines
413	N Indonesia & Malaysia
414	S Indonesia
1011	Papua New Guinea

14. VARIED WEST COASTAL

611	Mexico
731	Peru & N Chile
742	S Argentina & S Chile
922	Angola & Namibia
923	Union of South Africa

15. UNITED STATES

513	Contiguous United States

16. AUSTRALIAN REGION

1012	Australia
1013	New Zealand

17. HIGH LATITUDE SEAS

1222	Gulf of Alaska
1324	Iceberg Atlantic
1312	Rockall Atlantic
1311	Norwegian & Greenland Seas
133	North Cape Area
132	Barents Sea
131	Sea of Okhotsk
134	Komandorksy - Bering Sea
1243	W Drake Passage Pacific
1334	South Georgia Atlantic
1433	Macquarie - Antipodes So

18. MID-LATITUDE SEAS

1223	Midway - California Pacific
1323	Bermuda Atlantic
1322	Sargasso Atlantic
1313	Gibraltar Approaches
135	Sea of Japan
422	East China & Yellow Seas
1211	Volcano Is., NW Pacific
1242	Kermadec - Chatham Pacific
1235	Easter Island Pacific
1333	SW Atlantic
1332	Tristan de Cunha Atlantic
1432	SW Indian Ocean
1431	Amsterdam Indian Ocean
1241	Tasman Sea

19. TROPICAL SEAS

1212	Former Trust Pacific
1213	Hawaii - Kingman Pacific
1214	Clipperton Pacific
622	Caribbean Sea
623	Gulf of Mexico
1321	Cape Verde Atlantic
1412	Arabia Sea
1411	Bay of Bengal
421	South China Sea
1231	Solomons - Samoa Pacific
1232	Jarvis - Cook Pacific
1233	French Polynesia
1234	S Galapagos Pacific
1331	Ascension Atlantic
1422	Seychelles - Mauritius
1421	Cocos Indian Ocean

REFERENCES

Fleiss, J. L., *Statistical Methods for Rates and Proportions*, Wiley, 1973.

Lowther, R. P., M. T. Surmeier, R. W. Hartman, C. R. Coffin, and A. J. Warren, *RTNEPH Total Cloud Cover Validation Study*, USAFETAC/PR—91/020, USAF Environmental Technical Applications Center, Scott AFB, Ill., 1991.